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July 1973 Ground Survey of Active Central American Volcanoes

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Summary Statements

Overall Status:

Reasonably good current ground truth is at hand. No predawn thermal imagery is yet available from Skylab of the test area.

Recommendations:

That predawn imagery be given high priority.

Expected Accomplishments and Summary Outlook:

Another set of ground truth observations will be collected in November. If imagery is obtained, data analysis will ensue.

Significant Results:

Ground survey has shown that thermal anomalies of various sizes associated with volcanic activity at several Central American volcanoes should be detectable from Skylab. Anomalously hot areas of especially large size (greater than 500 m in diameter) are now found at Santiaguito and Pacaya volcanoes in Guatemala and San Cristobal in Nicaragua. Smaller anomalous areas are to be found at at least seven other volcanoes. This report is completed after ground survey of eleven volcanoes and ground based radiation thermometry mapping at these same points.

Travel Summary:

The investigators visited Guatemala, El Salvador and Nicaragua in the months of June and July.

Personnel:

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Volcano Site Reports:

Santiaguito

Fuego

Acatenango

Pacaya

Izalco

Tecapa

San Miguel

Cosiguina

San Cristobal

Telica

Cerro Negro

Masaya

Date August 1973

Volcano Santiaguito

Location Guatemala, 14° 45.5' N 91° 32.9' W

Dates of latest information 4 July 1973

Dates and locations of PRT-5 Work

3 July from Buena Vista, 2.0 Km N of the Caliente vent.

4 July from La Loma trail, about 0.7 Km NW of the Brujovent.

PRT-5 Summary

Anomalously hot surface temperatures in areas near both the Caliente vent and the Brujo vent.
Volcanic Activity Summary *

No pyroclastic activity since the Nuée ardente^e of April 1973. Lava flow activity continues from both the El Brujo and Caliente vents. Incandescent rockfalls have been observed at both ends of the volcano in July, indicating the movement of these blocky flows. Both flows are large. The Brujo flow is now more than 1 Km longer than a year ago; it is flowing down the valley of the Río Concepcion, having overflowed the loma. The Caliente flow has continued flowing down the east and southeast slope of the dome, and has effectively blocked the barranca draining the 1902 crater. The Caliente flow began January 1972, the Brujo flow in December 1971.

Expected Thermal Anomalies

- 1) Large anomaly approximately 1000 x 500 m on the west end of the dome, coinciding with the Brujo flow.
- 2) Large anomaly perhaps 500 m+ in diameter extending from the Caliente vent eastward.
- 3) Small anomalies (a few meters in diameter) associated with fumarolic areas (Sapper, Bonis, vonTuerckhein) on the central parts of the dome.
- 4) Possible anomaly in valley of Río Nimá II, opposite Mirador La Florida, where the ash flow of April 19, was producing secondary steam explosions in early July.

Investigators Rose, Lange, Malone, Crafford

*see addenda: April 1973 Nuee ardente at Santiaguito Volcano

Date August 1973

Volcano Fuego

Location Guatemala, 14° 28.9' N 90° 52.9' W

Dates of latest information 6 July 1973

Dates and locations of PRT-5 Work

6 July 1973 from just north of Alotenango, 8.5 Km E of summit.

PRT-5 Summary

A slight warming (2-3 degrees) noted around the crater edge.

Volcanic Activity Summary *

No eruptive events since the February-March 1973 sequence of ash explosions. The gas plume is large, however.

Expected Thermal Anomalies

- 1) The summit crater
- 2) A fumarolic area a few hundred meters to the NE of the summit.
- 3) Possible anomalies in several barrancas, mostly on eastern flanks, associated with avalanches of February 1973.

Investigators Crafford, Malone, Lange, Carr

*See Bonis, 1974, Bull. Volcanol., v. 37, in press.

Date August 1973

Volcano Acatenango

Location Guatemala, 14° 30.2' N 90° 52.4' W

Dates of latest information 27 June 1973

Dates and locations of PRT-5 Work

None, except that done on Fuego.

PRT-5 Summary

None

Volcanic Activity Summary

Three fumaroles presently active in a line due north of the summit. The temperature of the northernmost of these was 435°F. This was the smallest of the three, which are spaced about 20 meters apart. Ash eruptions, which did occur from these fumarolic vents, beginning in October 1972, have now terminated, the last certain record of these is in January.

Expected Thermal Anomalies

A line of anomalies between the summit of Acatenango and Yepocapa, the lateral cone to the north, is very likely.

Investigators Malone, Crafford

Date August 1973

Volcano Pacaya

Location Guatemala, 14° 23.0' N 90° 36.2' W

Dates of latest information 5 July 1973

Dates and locations of PRT-5 Work

2 July from Cerro Chino, 1 Km NNW of crater.

5 July from triangular hill near El Patroncinio, 2 Km WSW of crater.

PRT-5 Summary

Distinct anomalies from background values (9-12°C) at the MacKenney crater (up to 34°C) and on the new SW flank flows (up to and above 75°C).

Volcanic Activity Summary

The crater shows very small explosions with ash. The lava flow on the SW flank has slowed markedly, perhaps ceased. There was a period of rapid lava discharge in May and early June, but by 27 June flow was very slow moving (1 m/min) near the vent. No movement observed on 5 July. This flow activity, begun in October 1972, has produced a large volume (probably several million m³) of new lava, forming a large triangular area SW of the active crater.

Expected Thermal Anomalies

- 1) The active crater west of the main summit, an area about 500 m in diameter.
- 2) The SW flank of the cone where the most recent (October 72-July 73) lava flows have occurred.
- 3) The February 1972 lava flow from below Cerro Chino, almost to El Patrocinio.

Investigators Lange, Stoiber, Malone, Rose

Date August 1973

Volcano Izalco

Location El Salvador, 13°48.9' N 89°38.1' W

Dates of latest information 7 July 1973

Dates and locations of PRT-5 Work

7 July 1973 from Hotel de la Montaña, about 1 Km NE of the crater.

PRT-5 Summary

Only a 2 degree anomaly registered, near the 1966 lava flow vent.

Volcanic Activity Summary

Nothing at all. Fumaroles still cooling, temperatures of these vents between 100 and 300°C.

Expected Thermal Anomalies

- 1) The crater, and especially two areas on opposite sides of the inside rim, may cause small (several meters diameter) anomalies.
- 2) Possibly an anomaly at or above the 1966 lava vent.

Investigators Rose, Lange, Crafford

Date August 1973

Volcano Tecapa

Location El Salvador, 13° 29.8' N 88° 30.2' W

Dates of latest information 7 July 1973

Dates and locations of PRT-5 Work

None

PRT-5 Summary

Volcanic Activity Summary

No activity, except fumarolic.

Expected Thermal Anomalies

1) El Tronador, a solfatara area on the NNW slope of the volcano. Temperature of these vents is just over 100°C.

2) Laguna de Alegría itself has very weak fumarolic activity; the temperature of the lake on 7 July was 26°C, exactly the air temperature. Still there is weak steam emission, especially on the west side of the lake.

Investigators Rose, Lange, Crafford

Date August 1973

Volcano San Miguel

Location El Salvador, 13° 26.2' N 88° 16.3' W

Dates of latest information 8 July 1973

Dates and locations of PRT-5 Work

8 July 1973 from Milians Motel, about 10 Km NNE of the crater.

PRT-5 Summary

No anomalies detected.

Volcanic Activity Summary

Strong fumarolic activity, but local inhabitants clearly agree that not even minor ash eruptions have occurred since 1970. Slumping has definitely occurred within the crater, enlarging the inner crater along an arcuate fracture which formed in the NW edge of the old inner crater (see sketch map). Steam emission was strong from the bottom of the 200 m deep crater - some pulsation in the emission was noted and a strong SO₂ odor is sensed.

Expected Thermal Anomalies

1) The deep crater bottom and several scattered fumaroles, all within the inner crater walls. The crater is about 400 x 300 m., elongate NW.

Investigators Rose, Lange, Crafford

Date August 1973

Volcano Cosiguina

Location Nicaragua, 12° 58' N 87° 35' W

Dates of latest information 19 July 1973

Dates and locations of PRT-5 Work

None

PRT-5 Summary

Volcanic Activity Summary

No activity. Greenish yellow lake in inner crater. Hydro-thermal alteration on south inner wall of crater.

Expected Thermal Anomalies

Uncertain

Investigators Stoiber, Malone

Date August 1973

Volcano San Cristobal

Location Nicaragua, 12° 42' N 87° 1' W

Dates of latest information 10 July 1973

Dates and locations of PRT-5 Work

10 July 1973 from Villa Salvadorita road 8.5 km NW of cone.

PRT-5 Summary

No thermal anomalies on NW side of cone detected.

Volcanic Activity Summary

Unchanged. Strong fumarolic emission from nested crater. Fumarole temperatures reach at least 100°C. The current type of activity began in May 1971.

At 3 fumaroles, 2 within the crater, one on the outer slope, the temperature, Cl and SO₄ content of condensates did not change materially throughout 1972. 1973 data not at hand.

Expected Thermal Anomalies

The crater itself, about 1000 x 600 m. The innermost crater, probably the hottest, is only 80 m or so in diameter. The visibility within the crater is always very limited, but temperatures of the crater floor have been reported as high as 270°C, and there may be a new dome within the innermost crater.

Investigators Rose, Lange, Malone

Date August 1973

Volcano Telica

Location Nicaragua, 12° 36' N 86° 52' W

Dates of latest information 11-12 July 1973

Dates and locations of PRT-5 Work

12 July 1973 from barranca 4 km S of crater.

PRT-5 Summary

No thermal anomalies detected on south slopes.

Volcanic Activity Summary

No eruptive activity. Regular gas emission, mostly concentrated in a single gas jet at or near N edge of crater. The last ash eruption activity at Telica was in 1971. A lava lake deep within the crater was also observed in that year. No inspection of the crater from the rim has been made this year.

Expected Thermal Anomalies

The crater itself, about 300 m in diameter.

Investigators Rose, Lange, Crafford

Date August 1973

Volcano Cerro Negro

Location Nicaragua, 12° 31' N 86° 44' W

Dates of latest information 10-11 July 1973

Dates and locations of PRT-5 Work

11 July 1973 from near farmhouse, less than 1 km South of the cone.

PRT-5 Summary

Hottest temperatures (up to 29°C) were recorded at the crater rim.

Lower temperatures downwards (lowest was 20°C).

Volcanic Activity Summary

No activity since February 1971. Fumarolic activity is still as strong and hot as ever, however. Highest temperatures (300°C) recorded at the base of a spine 75 m below the east crater rim, and 15 m above the crater bottom. There are fumaroles also on the west and north walls of the crater (T = 100°C). A "hot area" is also found on the crater rim and extending 15 m into the crater on the east side (above the spine). This latter observation is new this year.

Expected Thermal Anomalies

- 1) The crater itself, now 270 x 225 m and 130 m deep. Especially the east side of the crater from the rim to the bottom.
- 2) Possibly the 1968 flow will still be anomalously warm, especially near Cristo Rey.
- 3) A fumarolic area on the east flank of the cone, about 1/2 way up which was a lateral lava vent in the 1950's.

Investigators Stoiber, Lange, Carr, Crafford

Date August 1973

Volcano Masaya

Location Nicaragua, 11° 57' N 86° 09' W

Dates of latest information 16 July 1973

Dates and locations of PRT-5 Work

17 July 1973 - from NE rim of Santiago crater.

PRT-5 Summary

Variable temperatures on lava lake surface from 22°C to greater than 75°C at the gas vent.

Volcanic Activity Summary

Lava lake cooling (?). Steam emission from an incandescent gas vent. Fumarolic activity elsewhere on lava lake surface.

Expected Thermal Anomalies

The lava lake in the crater itself, about 300 m in diameter.

Investigators Stoiber, Lange

PRT-5 Detailed Summary - July 1973

Ian Lange
August 1973

Pacaya - July 2 - from Cerro Chino
Distance from station to summit 1 km.

Background temperature 9° to 10° C decreasing upward along left side but increasing as approach new crater on right side of summit. Highest observed temperature was 34° C.

Station air temp. was 53° F
Time: 4:30 to 5:50 A. M.
Winds: 10-20 mph
Atm. conditions: clear except for smoke over western
or right side of cone.

Santiaguito - July 3 - from Buena Vista
Distance from station to Caliente crater 2.0 km.

Background temperature 8° to 9° C, which increases upward over whole domal complex. Highest reading over Caliente crater 23° C. Highest reading over El Brujo off scale hot.

Station air temp.: start 50° F end 49° F
Time: 4:45 to 5:55 A. M.
Wind: 10-15 mph
Atm. conditions: very clear

Santiaguito - July 4 - from La Loma Ridge
Distance from station to El Brujo is 0.7 km.

Background mountain temp. was 11° C. Highest temperatures were off scale hot and were on the lava flow. Warm outcrops occur to the left (north) of the lava flow.

Station air temp. at start was 58° F and end 59° F
Time: 4:55 to 5:48 A. M.
Wind: light
Atm. conditions: clear

Pacaya - July 5 - from knob west of cone
Distance from station to old summit cone is 2 km.

Lower mountain background temp. was 11° to 12° C. Hottest readings were on the new lava flow which was still giving off blue haze - smoke (48° C). Highest temperature in new crater was 20° C. The 1971 flow is still slightly warmer than background temperatures and a 4° C warmer anomaly was noted above and left of the most recent lava out pourings.

Station air temp.: start 62° F, end 60° F
Time: 4:15 to 5:25 A.M.
Wind: 10 to > 20 mph
Atm. conditions: clear, but blowing steam over right side of cone.

Fuego - July 6 - from the road just outside and north of Alotenango
Distance from station to summit was approx. 8.5 km.

Background temperatures range from 9° C below the summit to 14° C in the trees well below the summit. A slight warming was noted around the crater edge (2° to 3°) warmer than background.

Station air temp: start 64° F, end 58° F
Time: 4:43 to 5:27
Wind: light
Atm. condition: clear

Izalco - July 7 - from Cerro Verde
Distance from station to summit is approx. 1 km and NNE of summit.

Background temp. just below summit was 12° C to 13° C increasing downward 14° C. Slightly warmer temperatures up to 20° C were noted at the summit. On the SE flank near the 1966 vent temperatures were 2° C warmer than background.

Station air temp.: start and finish 58° F
Time: 4:35 to 5:57 A.M.
Wind: light
Atm. condition: clear

San Miguel - July 8 - from the Motel in San Miguel
Distance from station to summit is 10 km.

Background temperatures decreased from summit downward from 21° F to 23° F in the vegetation. No anomalies were detected.

Station air temp.: start 74° F, end 75° F
Time: 5 to 5:12 A.M.
Wind: none
Atm. Conditions: clear

San Cristobal - July 10 - from main road to left of foreground knob
Distance from station to summit 8.5 km.

Temperatures decreased from 21° C background near summit to 23° to 24° down into 16 trees. No anomalies seen on the crater.

Station air temp.: 80° F to 85° F
Time: 5:25
Wind: light
Atm. conditions: clear, except for variable blowing steam and smoke on the summit and right side of cone.

Cerro Negro - July 11 - from near farmhouse, 100 m S of parking lot.
Distance from station to summit <1 km.

The lowest temperature recorded was 20° C. Temperatures increased upwards to a maximum of 29° C on the crater rim. General rim crater temperatures were between 22° and 24° C.

Station air temp.: start 78° F, end 70° F
Time: 5:25 to 6:20 A. M.
Wind: none
Atm. conditions: clear

Telica - July 12 - from a stream gully off the main pass road
Distance from station to summit is 4 km.

No anomalies were detected. Temperatures increased downward from the summit from 25° C to 26° C.

Station air temp.: start 81° F, end 77° F
Time: 5:45 to 6:10 A. M.
Wind: calm
Atm. conditions: clear

Masaya - July 16 - from the crater rim
Distance to crater floor: 180 meters.

We made two traverses across the floor and at right angles to one another. The highest temperatures were in the "red" steamy hole which was off scale hot ($>75^{\circ}$ C). Temperatures on the floor were quite variable with a low of 22° C in places. Average floor temperatures were 23° to 25° C, while the hottest reading, other than the "red hole", was 53° C.

Station air temp.: start 74° F, end 70° F
Time: \approx 5:00 A. M. to 5:40 A. M.
Wind: very light
Atm. conditions: very clear, except in the crater where steam was very variable as it rose.

Addenda:

April 1973 Nuée ardente at Santiaguito volcano

Pacaya volcanic activity, 1972

Nuée Ardente from Santiaguito Volcano
April 1973

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ABSTRACT

The largest nuée ardente eruption of Santiaguito since November 1929, occurred April 19, 1973. The nuée descended the valley of the Río Nimá II for a distance of about 4 km. The ash flow itself was restricted to the river bed, but the hot gas cloud devastated an area of more than 3 square kilometers extending hundreds of meters on both sides of the river bed. Because the ash cloud stopped about 2 km from the nearest habitations, there were no fatalities.

Introduction

During the night of April 19, 1973, Santiaguito volcano produced its largest *nuée ardente* in 40 years. The eruption occurred on a cloudy night so no direct visual observations were reported from inhabited areas. By far the dominant recollection of inhabitants at plantations 7 km south of Santiaguito was a nearly unbearable SO_2 gas odor, which was accompanied by steady rumbling. Ash fell in areas to the west and south of Santiaguito, the maximum reported thickness of new ash was 10 cm.

Field Observation

Some details of the eruption can be reconstructed from field examination of the area affected. The eruption came from the Caliente vent, which occupies a position in about the center of the 1902 explosion crater of Santa María and which has been the principal pyroclastic vent throughout all of Santiaguito's 51 year history of activity. An ash flow descended the southeast flank of Santiaguito and entered the valley of a tributary of the Río Nimá II. This tributary has (since the 1950's) been draining the 1902 crater of Santa María, until mid-1972, when a lava flow from the Caliente vent reclosed the crater. After entering the river valley, the ash flow simply followed the steep-walled canyons downstream for a distance of about 4 km, to a point below the Mirador of La Florida. At this point the ash flow material is still more than 2 km from the nearest habitation, the finca La Florida. The ash flow itself was restricted to the river channel, which is nowhere wider than about 20 meters. Near the La Florida mirador, the ash flow material was constricted in a band of the

channel, and accumulations of hot material was still producing secondary steam explosions more than two months after the eruption. Such explosions are quite a common feature of ash flow activity; they were well described by ANDERSON and FLETT (1903) at St. Vincent. They occur when hot ash in the river bed is invaded by river water. Local reports that this emission was due to the opening of a new crater are erroneous.

The most dramatic effects of the eruption occurred on the slopes of the Río Nimá II drainage system above the river bed itself. Here a large area, more than 100 times the area of the ash flow itself, was devastated by the glowing cloud above the ash flow. The devastation provides an especially dramatic contrast since the local vegetation is very dense jungle. The area affected is about three square kilometers (Figure 1). Within the outlined area all green vegetation was destroyed. Near the river bed all trees were flattened, broken off at ground level, with the trunks (up to 1 m in diameter) either pointing in the direction of flow or transported away (Figure 2). Moving uphill away from the river valley toward the margins of the affected area, the intensity of the blast was obviously lessened, with some trees remaining upright. At the edges of the devastated zone many trees were upright; this was especially true where the forest was topographically shielded from the force of the blast (in the lee of a ridge). The boundaries of the devastated area were surprisingly abrupt, typically a transition zone of only a few meters was found, beyond which the vegetation was still verdant. The width of the devastated zone decreased in the downstream direction, apparently because the eruption dissipated as it moved.

The only event of Santiaguito's eruptive history which has a similarity to this April, 1973 eruption, was the great nuée of November, 1929, which killed several hundred people (SAPPER and TERMER, 1930). Even though Santiaguito has produced many nuée ardente eruptions, particularly in the periods of 1923-25, 1929-33 and 1967-68 (ROSE, 1973), except for the November, 1929 blast, events did not have devastating "hurricane cloud" zones in anything approaching the proportions of the April, 1973 event.

It would seem desirable as well as practical, to pay particular attention to the relative scales of the areas affected by 1) the ash flow deposit itself and 2) the turbulent hot gas blast cloud or "hurricane" cloud. Many events which are reported as "nuée ardentes" have a gas wave outside of the ash flow which has very limited proportions, often affecting less area than the ash flow deposit itself. Such events are quite different from what happened at Santiaguito in April, 1973.

Within the devastated zone the thickness of eruptive material deposited on the ground was minimal -- at most only a few centimeters. The material is powdered dacite, with very poor sorting and many fragments of 5 cm or more in diameter. This material was transported by a hurricane force gas cloud. The density of the cloud allowed it to effect damage which could only be produced by even higher velocity winds, if no suspended rock chips were involved. Heat effects inside the devastated area were interesting. Again there was a gradation from the river bed toward the borders, with burned tree trunks common near the valley, and with only baking or singeing effects near the margins. It is thus clear that most of the area was not subjected to temperatures much in excess

of about 200°C, though the rock chips transported by the gas blast may have been hotter; retaining their heat in proportion to their size.

Discussion of many of the same characteristics can be found in TAYLOR (1958) who detailed the effects of Mt. Lamington's great eruption in 1951. That event had a much larger devastated zone (200 km² vs 3 km²) and produced far more pyroclastic material, but otherwise was very much like the recent Santiaguito blast.

Discussion

The occurrence of this kind of dangerous eruptive event is obviously of great environmental importance to the coastal slope of Guatemala below Santiaguito. The eruption of November 1929, was of a similar type, but extended at least 2 km farther from the dome and affected the valleys of the Río Tambor and Río Concepcion (to the west) as well as the Río Nimá II. It is the same area that would now be affected if a larger eruption should occur. The closest inhabited site that would be affected is Finca La Florida.

Other areas near the valleys of the Tambor and Nimá II (Finca El Patroncinio, Finca Santa Marta and the town of El Palmar) are much farther away, but would still be expected to be in some danger if another eruption came. As one moves farther downstream the danger would be more apt to be from mudflows than from ash flow or hot gas clouds. Since none of the inhabited areas are directly within the river bed, most of the danger to the populace would seem to be from the hurricane cloud effects. TAYLOR (1958, p. 49) has indicated that it seems most likely that the principal cause of death in the case of the Lamington event was not the temperature within the cloud or

poisonous gases inhaled, but hot dust which was inhaled. People in the open were killed, those in well-closed rooms survived. It would seem that a simple gas mask would afford an extra edge of protection from hot ash inhalation, and that these masks might be a useful safety investment at least for people living at the finca La Florida. People who would not have time to evacuate the area might have time to reach a conveniently placed gas mask and some kind of closed shelter. A small, inexpensive lightweight gas mask could be carried in the pocket by those working far from shelter.

It is impossible to know whether another such event is likely in the near future. But little about the character of activity at Santiaguito has changed since early 1970. Blocky lava flows are still being extruded from both the Caliente vent and the El Brujo vent, 2 km to the west. The Caliente vent is still obstructed by a large lava plug -- no obvious crater was created by the April eruption. A large gaseous plume is still being emitted through the blocky plug dome at the Caliente vent, as was the case for two years before the April, 1973 eruption. During lava flow activity at other lateral vents, nuées with very limited gas clouds have been observed (STOIBER and ROSE, 1969), but nuées with large "hurricane" clouds are only produced when lava flows are being extruded from the Caliente vent. The significance of this fact with respect to the mechanism of volcanic activity at Santiaguito is obscure -- it is only an empirical observation. There was a two-year repose interval between the last Caliente pyroclastic activity and the April, 1973 eruption. This is judged to have little predictive significance based on past activity in Santiaguito.

Perhaps most significantly, no sign of any more pyroclastic activity or nuées from the Caliente vent has occurred in more than 2-1/2 months since

April 19. A report of some activity on June 7, is almost certainly false. Only small, very frequent incandescent rockfall activity down the east and southeast slopes of the Caliente dome has been observed, indicative that the blocky flow is still active. One other facet of the current activity may have some significance ultimately to local residents. The newest blocky flow from Caliente vent has dammed the 1902 crater at the east end, as mentioned above. A lake is forming now in the crater, as was the case in 1902-22 and probably in the 1940's. If this lake should fill to the level of the dam, a catastrophic overflow which would breach the dam is possible. Such overflow would almost certainly produce a mudflow which would descend the Río Nimá II and possibly the Río Tambor. This event could occur without an eruption and suggests that the crater lake should be observed periodically to know if any likelihood of such an event exists.

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Figure Captions:

Figure 1: Map showing the extent of the area affected by the April 1973 nuée ardente. Squares symbolize inhabited locations. North is to the top, contour interval is 500 meters. Base maps obtained from Instituto Geográfico Nacional, Guatemala City.

Figure 2: Photograph showing devastation of forest just inside the edge of the affected zone of Figure 1. Trees as large as 1 m in diameter were denuded and broken off, their trunks all pointing in the direction of movement of the nuée (to the left in the photo).

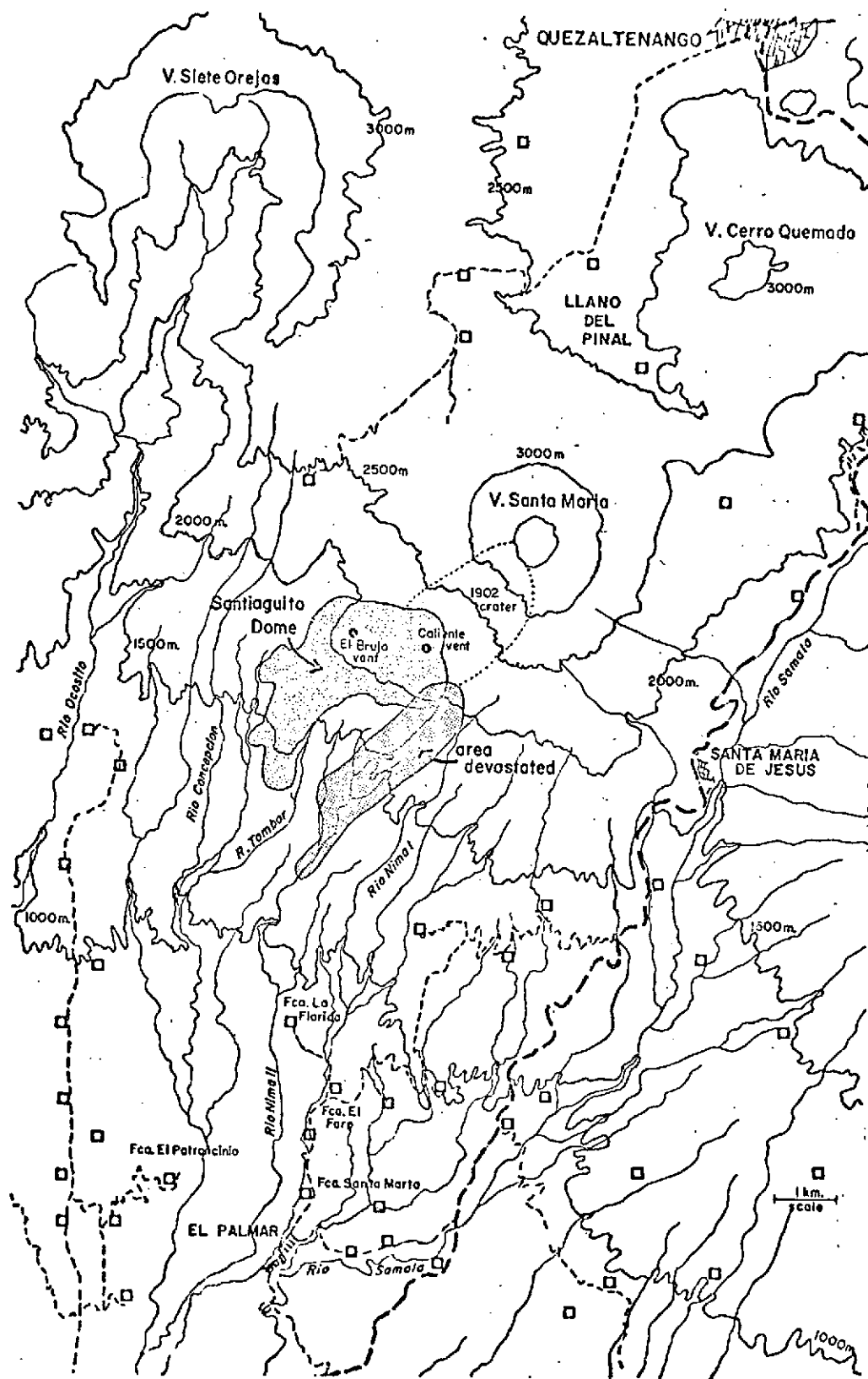


fig 1

February 1972 lava flow(s)

The flow was extruded in about nine days, February 2-11.¹⁾ The source vents were on the lower slopes of Cerrochino and Pacaya and in the valley between (B, C, D and E on Figure 1 attached). The area covered by this new flow is 1.4 km²; its average thickness is greater than 2 m. Thus, the volume of lava produced is about 3×10^6 m³. If averaged over nine days, the rate of magma production is about 300,000 m³/day. Observations during the eruption determined that during the first days of activity the magma production rate was in excess of 400,000 m³/day.²⁾ As the eruption went on, this rate decreased and the activity shifted from vents near D, C and B entirely to vents near E. The age of a small flow from vent F is uncertain.

The new lava is virtually identical to other historic Pacaya lavas. It is a porphyritic olivine basalt, with large (up to 6 cm) plagioclase phenocrysts.

October - December 1972 flow(s)

About October 15³⁾ lava flow activity resumed, this time from vents on the southwest flank of the Pacaya cone (G, H and I). The magma production rate was much more variable and generally much less than that of the February eruption. Also, the duration of the active period (at least 60 days) was much longer. On December 3, the magma production rate was observed to be 800 m³/day, all coming from vent H. Only two days later (December 5) the rate was 20,000 m³/day. The total volume of new lava by December 5 (after 50 days of activity) was in excess of 300,000 m³, or only equivalent to one day's production at the February rate. Viscosity estimates of the lava streams near vent H observed on December 3, 4 and 5 gave values of between 10^5 and 10^6 poises. The newest lava is petrographically like the others.

Volumes of lavas produced at Pacaya

Small lava flows have occurred at least 17 times⁴⁾ since the current activity began in 1965. Except for the late 1972 flows, none approached the size of the February 1972 flow. Many were very small, no more than 20,000 m³. The total volume of lava flows produced in the 1965-1971 period probably did not exceed 2×10^6 m³. The volume of pyroclastic material produced in the same period can be estimated by use of profiles like those of Figure 2. This figure suggests that at least 30 m of pyroclastics have been deposited near the crater rim. At the same time the mild nature of pyroclastic activity at Pacaya did not scatter ash any great distance from the cone except on a few occasions. Based on a conical model calculation, the value of pyroclastics produced at Pacaya in the period 1965-72 is estimated at 2×10^6 m³.

A previous estimate of the 1961 Pacaya flow (from vent A) was $1.5 \times 10^6 \text{m}^3$. 5) Because the area covered by this flow was greater than that of the February 1972 unit ($> 3 \text{ km}^2$), and because the thickness is roughly the same, the true volume of 1961 lava is probably about $6 \times 10^6 \text{m}^3$. Thus, the total volume of lava produced since 1961 at Pacaya is in excess of 10^7m^3 .

- 1) Smithsonian Ist. Cent. Short-Lived Phen., card 1356, 17 Feb. 1972.
- 2) T. Loucks, pers. comm., 13 Mar. 1972.
- 3) Smithsonian Inst. Cent. Short-Lived Phen., card 1519, 27 Dec. 1972.
- 4) Eggers, A.A., 1971, The geology and petrology of the Amatitlán Quadrangle, Guatemala, Ph.D. thesis, Dartmouth College.
- 5) Bohnenberger, O.H., 1969, Report on Active volcanoes in Central America during 1957 to 1965, Bull. Volc. Eruptions, No. 9-1, p. 16-19.

